Ice nucleating particles atmospheric concentration at San Pietro Capofiume (Italy): local sources and long range transport

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Ice in clouds is formed prevalently via heterogeneous nucleation involving aerosol particles known as ice nucleating particles (INP). INP can form ice through different thermodynamic mechanisms: deposition, condensation-freezing, immersion and contact. It is generally agreed that ice will form on nuclei in response to different thermodynamic forcing, the primary variables being temperature, and the saturation ratio with respect to ice and water (S_{ice} and S_w, respectively).

Two experimental campaigns were carried out at at the Meteorological Station "Giorgio Fea" in San Pietro Capofiume (SPC), a rural background site located at about 30 km nord-est of Bologna, in the periods 07-21 February 2014 and 19-30 May 2014. Aerosols (PM1 and PM10) were sampled on nitrocellulose membrane filters (Millipore, porosity 0.45 μm), two times a day (9 am and 2 pm). Simultaneous measurements of particle number concentration in 15 different size classes starting from 0.3 μm were also performed by Optical Particle Counter (OPC, Grimm, Mod.1.108).

Concentrations of INP were detected by the membrane filter technique, using a diffusion filter processing chamber (DFPC). The DFPC is a modified Langer and Rodgers (1975) chamber in which supersaturation with respect to water is obtained by air flowing through fine milled ice (Santachiara *et al* 2010). Measurements were made at $S_w = 0.96$ and $S_w = 1.01$. In both cases the temperature of the filter was -18°C. Measurements below water saturation should allow the detection of deposition nuclei, while those above water saturation should allow the detection of deposition and condensation-freezing nuclei.

The concentration of INP observed at SPC during the two campaigns ranges between 5 and 251 m^{-3}, for S_w=0.96 and between 21 and 908 m^{-3} for S_w=1.01 (in Fig. 1 the average values are reported). The results show INP concentrations predominantly higher in the morning than in the afternoon, likely due to the effect of the boundary layer height.

Typically, the PM1 fraction accounts for at least 60% of the atmospheric concentration of INP, with the exception of the first campaign (February 2014), where PM1 contributed only for 20-25%, at S_w=1.01. This evidences the need to measure the freezing activity even in particles larger than one micrometer.

The comparison with the total particle number concentration in the ranges 0.5-1 μm and 0.5-10 μm, shows that INP are in the order of one every 10^5-10^6 particles, in both PM1 and PM10 size ranges.

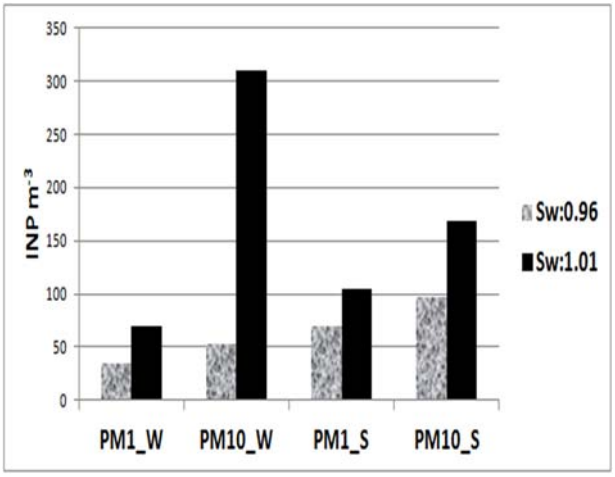

Figure 1. INP concentration (m^{-3}) at SPC for the winter (W) and spring (S) campaigns.

Saharan dust transport episodes were observed during both campaigns. These episodes are characterized by increased INP concentration in the PM10 size range, particularly for S_w=1.01, with INP concentration in the PM1 size range comparable to those measured during the remaining days, and enhanced total super-micrometer particle concentration.

Results show a decrease of the activated fraction during these events, in contrast with the observations of Chou *et al* (2011) during dust events at Jungfraujoch (3580 m a.s.l). This difference can be likely explained by the different temperature (-31 vs. -18° C) at which the measurements were operated, as mineral particles tend to be more efficient INP at lower temperatures.

The influence of Saharan dust transport episodes on the INP population over the Po Valley, with respect to local sources, will be investigated based on the above case studies.

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